Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE CHESTER SERIES IN ILLINOIS

STUART WELLER
University of Chicago

PART II

UPPER CHESTER GROUP

Tar Springs sandstone.—Like the Lower and Middle Chester groups the Upper Chester is initiated by an important sandstone formation which is named the Tar Springs. This name was first used by Owen many years ago for a sandstone in Breckinridge County, Kentucky, and has been revived by Butts[1] at a recent date. This sandstone is a persistent formation across Hardin, Pope, and Johnson counties, as far as the detailed mapping has been carried, and it doubtless continues into Union County. The sandstone is variable in character. In some places in the area which it occupies it is as massive and as conspicuous a cliff maker as the Cypress; this is especially true in some portions of Hardin County. Elsewhere it is nearly all thin-bedded. Much of the sandstone is conspicuously cross-bedded. Throughout much and perhaps the whole of the Chester belt across the southern counties, the Tar Springs sandstone is divided into an upper and lower member by a persistent shale bed, which has associated with it in widely separated localities a thin layer of impure coal, in some places only an inch or two in thickness but elsewhere a foot or more. The more massive layers of the sandstone resemble the Cypress and Hardinsburg in color and texture, but in much of Pope and Johnson counties, where the formation is more thinly bedded, it is distinctly darker brown than any of the older Chester sandstones.

The thickness of the Tar Springs sandstone varies considerably. In Hardin County it is one hundred feet or more thick, perhaps as much as one hundred and fifty feet locally, but it diminishes to the west, and in western Johnson County there are places where it is apparently not more than forty feet. In tracing the horizon into the Mississippi Valley counties, the Tar Springs disappears entirely, there being not even such a thin discontinuous sandstone horizon as that which represents the Hardinsburg, the position of the sandstone being occupied by a plane of unconformity above the Upper Okaw or Glen Dean limestone.

---

[1] *Mississippian Formations of Western Kentucky* (1917), p. 103.

Vienna limestone.—The Vienna limestone is named from Vienna, Johnson County, Illinois, where the formation is exposed in some of the streets of the town, and in an old quarry just west of the town. As it is commonly exposed, the Vienna exhibits two rather distinct facies, an exceedingly siliceous limestone in the lower portion of the formation, and a shale member above. In places the limestone seems to comprise the greater portion of the formation, but in other localities it is mostly all shale, with but little of the limestone present. As already stated the limestone is remarkably siliceous. The silica is in part in the form of chert layers, and in part is finely disseminated through the limestone. On weathering, the limestone with the disseminated silica loses the lime by solution, and the residuum is a light, yellowish-brown, porous rock, which on first inspection resembles a fine-grained sandstone, but which contains no sand grains whatever. The chert of the formation is quite persistent in character, the beds commonly being from one to four inches thick and quite regular. Near the surface the upper and lower portions of these chert beds have been subjected to some decomposition and are much lighter in color for a fraction of an inch in depth than is the deep chocolate brown of the central portion of the beds. As the limestone with the chert layers is removed by weathering, the cherts fracture into subcubical masses with two light-colored surfaces, and occur in abundance in the residuum. Less commonly there are some thicker chert beds, six to eight inches, which are more or less porous in character. The peculiar character of the weathered products of the Vienna limestone make it about the easiest to recognize of any of the limestone formations of the whole Chester series. The shales of the Vienna are black, fissile, and non-calcareous.

The siliceous limestone facies of the Vienna has been recognized from eastern Pope County, across Pope and Johnson counties, and into the eastern part of Union County, except where the formations are interrupted by faulting. The black shale facies of the same formation probably extends eastward beyond Pope County into Hardin. It has been recognized considerably farther west in Union County than the limestone, but it is not unlikely that the limestone will be found to extend farther in that direction when the detailed mapping is carried across Union County.

North of Golconda, in Pope County, a measured section through the Vienna formation gives a thickness of seventy feet. This is perhaps the maximum thickness that is known, and the average thickness throughout the area occupied by the formation is probably about sixty feet, perhaps becoming considerably thinner than this to the east.

The fauna of the Vienna limestone has certain characteristics which distinguish it from the other limestones of the Chester series. The *Prismopora* so characteristic of the Glen Dean limestone is present somewhat commonly in the Vienna in places, but it has never been observed to be so abundant as it is in some localities in the older formation. Associated with the *Prismopora* there is found somewhat rarely the pelecypod species *Sulcatopinna missouriensis*, which is highly characteristic of the next higher limestone in the Chester series, the Menard. This notable mingling of the Glen Dean and Menard species is perhaps the leading characteristic of the fauna as a whole, although further studies of the fauna must be made.

In the absence of any representative of the Tar Springs sandstone in the Randolph County section, the determination of the Vienna equivalent in the section, if there is such an equivalent, is rendered somewhat difficult. There is no lithologic unit present in Randolph County similar to the siliceous limestone of the Vienna, and no fauna has been recognized in which the Glen Dean and Menard forms are associated. There is, however, locally at least, lying above the Okaw limestone and beneath the typical Menard, a conspicuous black-shale horizon, which may be a continuation of the black shale of the Vienna in the southern counties. Further field studies may serve to prove or disprove this suggestion.

Waltersburg sandstone.—On Bay Creek, between Simpson and Grantsburg, near the line separating Pope and Johnson counties, there is a conspicuous sandstone formation overlying the Vienna limestone. The maximum thickness of this sandstone along Bay Creek is about sixty or seventy feet, but it is reduced in thickness both to the east and to the west. In an easterly direction the sandstone has been recognized at its proper position in the section nearly to Grand Pierre Creek in eastern Pope County. To the west it is known to extend, but much reduced in thickness, nearly to the Johnson–Union County line, and it may be found to continue into Union County. As viewed along an east-west section across the southern counties of Illinois, this formation is a lenticular body of sandstone with a lateral extent of nearly forty miles. The extent of the formation in a north-south direction is not known.

The importance of this unit in the Chester section was first recognized in Pope County, northwest of Golconda, where it is well exposed in the road just north of Waltersburg, from which locality the formation has been named, although it is by no means as thick at this point as it is farther west. In its area of maximum development the Waltersburg is a massive, cliff-forming sandstone, not conspicuously different in character or appearance from portions of the Bethel, Cypress, Hardinsburg, or Tar Springs sandstones. Where the formation approaches its lateral limits to the east and west, it is a thinly bedded, rather impure sandstone, in layers two or three inches thick, which are commonly distinctly jointed in two directions, one set of joints being placed at intervals of two or three inches, the other at a foot or more. These two systems of joints cause the rock layers to break up into elongate, splinter-like blocks which are rather characteristic. There are places where the entire formation is represented only by two or three feet of sandstone of this character, situated between the black shale of the Vienna below and the calcareous shales and limestones of the Menard above.

No fossils have actually been observed in the Waltersburg, but trunks of Lepidodendron, such as are found in the other Chester sandstones, may be expected.

Menard limestone.—The Menard limestone was originally named from the exposures in the Mississippi River bluffs at Menard, Illinois.[1] The formation is a persistent one in the Chester section of the Mississippi River counties of Illinois, from the point where the formation is first exposed from beneath the overlapping Pennsylvanian formations in Randolph County to where it passes beneath the surface in the Mississippi River bluffs in Jackson County. In the Mississippi River counties, where it was first described, the Menard was found to rest upon the Okaw limestone, the two limestones being rather sharply differentiated by both lithologic and faunal characters. It is now known that two important sandstone formations, the Tar Springs and the Waltersburg, are intercalated between these two limestone horizons in the Chester section of the southern counties, and also the Vienna limestone, unless it can be shown that this formation is represented by the black-shale bed that is at least locally present in Randolph County between the top of the Okaw limestone and the base of the more typical portion of the Menard.

In its typical expression the Menard is evenly bedded in layers about one foot, more or less, in thickness. The individual beds are separated by thin shaly seams or by beds of shale up to several feet thick, the surfaces of the limestone layers being distinctly hummocky. The limestone itself is commonly compact in texture, almost lithographic in places, hard and rather tough, breaking with a splintery or conchoidal fracture. The color of the limestone is commonly light gray, and the weathered surfaces are smooth in most places. These characteristics are quite in contrast with the crystalline beds of the Okaw limestone, with its more roughly weathered surfaces. An occasional bed of crystalline limestone is met with in the Menard, which might be mistaken for the Okaw if it were found alone.

Where the Menard limestone is exposed in the Chester belt across the southern counties, it can be easily traced across Union, Johnson, Pope, and Hardin counties, except where it is interrupted by faulting. Throughout this belt the limestone exhibits essentially the same lithologic characters as in Randolph County, except that the freshly broken rock is commonly darker in color, in some places nearly black, and it is associated with a greater amount of shale, one of the most calcareous shale beds at the base of the formation being highly fossiliferous. Near or perhaps at the very base of this limestone in the southern counties, a thin seam of impure coal, not more than two or three inches thick, has been observed in a number of localities and is perhaps a persistent band. A small amount of chert is present in the Menard, by no means so great a quantity as in the Vienna, but distinctly more than is commonly present in the Middle Chester limestones.

---

[1] Weller, *Trans. Ill. Acad. Sci.*, Vol. VI (1914), p. 128; also *Ill. State Geol. Surv.*, Monog. I (1914), p. 28.

The fauna of the Menard possesses many characteristics common to the Chester formations generally, but certain other features differentiate it quite sharply from those of the earlier limestones of the series. The species of the two genera *Spirifer* and *Composita* show a notable change in the Menard faunas from the earlier forms, in being larger and more robust in form. The typical examples of *Spirifer increbescens* are initiated in this horizon, and the typical *Composita subquadrata* takes the place of *Composita trinuclea*, which was the usual form in the older limestones. A very characteristic member of the fauna is the pelecypod *Sulcatopinna missouriensis*, which occurs in most Menard collections; in places it is very abundant, commonly standing vertically in the limestone strata, probably the position it occupied when living. This species occurs also in the Vienna limestone, but more rarely than in the Menard, where it is associated with the bryozoan *Prismopora serrulata*, which is unknown in the Menard. The most fossiliferous horizon in the Menard is the basal calcareous shale which is present in the southern counties, and which has been recognized across Hardin, Pope, Johnson, and Union counties. This bed is similar in character, both lithologic and faunal, irrespective of whether the underlying Waltersburg sandstone is thick, thin, or absent from the section. Among other forms which are commonly met with in this basal horizon is the blastoid *Pentremites fohsi*, and in the experience of the writer this species has been found in no other horizon.

The thickness of the Menard limestone in the Mississippi River counties commonly varies between sixty and eighty feet, but in the Kiskaddon well, near Bremen, there are eighty-five feet of strata referable to the formation. The average thickness may be assumed to be about seventy-five feet. In the southern counties the formation is somewhat thicker. In one measured section north of Golconda it is essentially one hundred feet, and that seems to be about the thickness of the formation commonly represented in the southern belt.

Palestine sandstone.[1]—The Palestine is the first of the sandstone formations of the Chester series which is present with essentially equal development both in the Mississippi River counties and in the southern counties of Illinois. The sandstone resembles the other Chester sandstones in its general features, but in only a few regions does it include notably massive beds, though such beds are present in the vicinity of Chester, Illinois, where it has been quarried for building stone. In general this sandstone is rather thinly bedded, in some regions including much shale which is more or less arenaceous in character. As commonly exhibited, the color of this sandstone is somewhat paler than most of the older sandstones of the series, and much of it, at least, is rather finer textured. None of these characteristics, however, are persistent enough to enable the formation to be readily recognized by its lithologic characters, and the only sure means of identifying it is from its relations with either the underlying or overlying limestones. Fossil tree trunks of the genus *Lepidodendron* occur more commonly, perhaps, in the Palestine than in any other sandstone of the Chester series, and one specimen six or seven feet long has been observed. No other fossils have been seen in the formation.

The thickness of the Palestine is not so great as that of some of the earlier Chester sandstones, although its geographic distribution is wider. In two measured sections in the Mississippi River counties the formation is sixty and sixty-seven feet respectively. In some other sections it is probably somewhat greater than this, perhaps as much as eighty feet. In the southern counties the maximum thickness of the formation is eighty feet, but in places it is considerably less, perhaps being as thin as forty feet in places. The average thickess of the formation throughout its entire extent is approximately seventy feet.

---

[1] Weller, *Trans. Ill. Acad. Sci.*, Vol VI (1914), p. 128; also *Ill. State Geol. Surv.*, Monog. I (1914), p. 29.

Clore limestone.—The Clore limestone was first described in Randolph County[1], and at the time it was believed to be the highest formation in the Chester series, but later observations have shown that it is succeeded by still another sandstone, and this again by a higher limestone formation. In many places the Clore really includes a larger amount of shale than it does limestone, locally the shale being much in excess of the limestone, and some ledges of the limestone itself are more or less shaly. The limestone beds of the formation exhibit a considerable amount of variation, some being compact and fine grained, others being shaly, some are hard and apparently siliceous, and a few beds are more or less crystalline. Nearly all of the limestone beds are more or less impure. The shale beds are almost entirely argillaceous or are more or less calcareous, the more calcareous beds having thin, platy layers of limestone imbedded in the shale. In the Mississippi River counties there is apparently a greater amount of limestone in the formation than in the southern counties, but wherever the formation occurs it is difficult to determine in detail its true composition, because of its non-resistent character and the consequent covering of surficial material.

The Clore is not a thick formation. Its thickness in two measured sections in the Mississippi River bluffs below the mouth of Marys River is between thirty and forty feet. In places, where it is the uppermost formation in the Chester series, it varies in thickness from forty feet down to nothing, due to the erosion of the higher beds. In the southern counties of the state the Clore is nowhere the highest formation of the Chester, and its lower and upper limits can rarely be determined with exactness. Furthermore both the lower and upper limits of the formation have nowhere been determined in one and the same section with any degree of accuracy. These conditions make the determination of the thickness of the formation in these counties rather uncertain, but numerous observations seem to establish a limit of about forty feet for the interval between the underlying and overlying sandstones in which it must be contained, which seems to establish a nearly uniform thickness in both of the two Chester areas of the state. As the formation is traced eastward, in the eastern part of Pope and in Hardin County, the Clore seems to become thinner even than the forty feet of the region to the west.

---

[1] Weller, *Trans. Ill. Acad. Sci.*, Vol. VI (1914), p. 129; also *Ill. State Geol. Surv.*, Monog. I (1914), p. 29.

The fossils of the Clore formation are numerous in places, and, like the faunas of all the other limestones of the Chester series, it possesses certain rather distinctive features. The general composition of the fauna is similar to that of other Chester horizons, being made up largely of bryozoans and brachiopods, with the axes of *Archimedes* and numerous species of Fenestellids being conspicuously present. The most significant feature of the fauna, however, is the abundance of small, cylindrical, branched bryozoa of the genus *Batostomella*, *B. nitidula* apparently being a conspicuous species. The fossils are most abundant upon the surfaces of thin limestone layers imbedded in some of the shales, and one such horizon is rather persistently present near the middle of the formation throughout most of the southern belt, and perhaps also in the Mississippi River counties as well. It is from this layer that the bryozoan-covered slabs of the Clore can be collected in great numbers. Among the brachiopods of the Clore fauna, large forms of *Spirifer increbescens* and *Composita subquadrata*, similar to those in the Menard limestone, are common in some localities.

Degonia sandstone.—During the earlier field studies in Randolph County, it was believed that the massive sandstone formation which was found to overlie the Clore limestone was the basal member of the Pennsylvanian, but during the progress of the field mapping of the Campbell Hill Quadrangle in the summer of 1919 by J. M. Weller, it has been found that this sandstone is succeeded by a still higher Chester limestone, which in turn is overlain by the true lower Pennsylvanian Pottsville sandstone filled with pebbles in many places. This sandstone, now known to be Chester, is especially well exhibited in the walls of several tributaries to the Mississippi River in Degonia Township of Jackson County, Illinois, and the name has been chosen from these exposures.

In southeastern Randolph, and in Jackson County to the valley of the Big Muddy River, the Degonia is a conspicuous cliff-forming sandstone, well exposed in the Mississippi River bluffs and in some of the tributaries to the Mississippi. In its massiveness the formation is perhaps more nearly comparable with the Cypress sandstone of the southern counties than with any other Chester sandstone, and where it is best exhibited it is commonly exposed in vertical cliffs forty or fifty feet in height, although the total thickness of the formation is considerably greater than this. The sandstone is somewhat coarser than most if not all of the other Chester sandstones, and is so much like some of the lower Pottsville beds of the adjoining regions, in localities where such beds are free from pebbles, that it is impossible, in places where the Kinkaid limestone is wanting, to always establish the line separating the Degonia from the Pottsville. Indeed this whole sandstone formation was considered to be Pottsville by Shaw, and was so mapped in the Murphysboro Quadrangle.[1]

In some sections, and perhaps in all, the whole of the Degonia is not as massive as the conspicuous cliff-making beds of the formation, but consists of thinly bedded or almost shaly sandstone in which the individual beds are undulating or curling, the undulations being irregular in character and having a width of only a few inches and a height of an inch or two. In places the more massive layers and the thinly bedded layers are arranged alternately in the sections, the units being variable in thickness up to fifteen or twenty feet. The total thickness of the Degonia sandstone throughout its extent in Randolph and Jackson counties varies only slightly from one hundred feet except where it is the highest formation in the Chester series and has been subjected to pre-Pennsylvanian erosion.

Of all the Chester formations the Degonia sandstone is most nearly continuous from the Mississippi River counties into the more southern area of the state, and further field studies may establish the complete continuity of the formation from one area into the other. In Jackson County the formation has been traced southward to the valley of the Big Muddy River. It is undoubtedly present in the Mississippi River bluffs south of the Big Muddy, and probably can be traced to northwestern Union County, where it will connect with the belt across the southern counties.

---

[1] *Geologic Atlas of U.S.*, Folio No. 185 (1912), p. 6.

In the southern counties the Degonia is continuously exposed from Union to Hardin counties. In Union County the thickness of the formation is in excess of seventy-five feet; at Simpson, in eastern Johnson County, it is at least one hundred feet thick; but farther east, across Pope and Hardin counties, it probably is somewhat reduced from the maximum thickness. There are places in Union County where the formation is fully as massive as in any of the sections in Jackson County, but to the east it becomes somewhat more thinly bedded, although massive layers are present in the formation throughout its entire extent in the state. In general, in its more eastern extension, the Degonia sandstone is rather paler in color and of finer texture than farther west, and in many places it resembles the Palestine somewhat closely.

The fossils of the Degonia sandstone are like those of the other Chester sandstones. The only forms that have been recognized are plant remains, and of these the *Lepidodendron* trunks are most commonly met with.

Kinkaid limestone.—The highest formation in the Chester series of Illinois is the Kinkaid limestone, named from the excellent exposures on Kinkaid Creek, in Jackson County. The formation is well developed in southeastern Randolph and in Jackson counties, and continues across the southern counties from Union to Hardin.

In its lithologic characters the Kinkaid more closely resembles the Menard than any other Chester limestone. It has been deposited in the same sort of regular beds about a foot, more or less, in thickness, the individual beds being separated by thin shaly seams, and the surfaces being distinctly hummocky. Many small exposures of the Kinkaid would be indistinguishable from similar exposures of Menard if the stratigraphic relations could not be determined. Some of the beds of the Kinkaid possess the same sort of compact, hard, close-textured limestone that is so commonly present in the Menard, but on the whole the Kinkaid probably includes a larger amount of somewhat more crystalline limestone than the Menard. In Randolph and Jackson counties no notable shale members have been recognized in the formation, and no conspicuous chert layers have been seen in place, although in some localities the residuum from the formation shows a considerable amount of broken chert.

In the southern counties the Kinkaid limestone is similar in character to the exposures in Jackson County; this is especially true in Union County, but as the formation is traced to the east it is found to include important shale beds and some very notable chert horizons. A very characteristic shale bed in the Kinkaid in Johnson and Pope counties, and perhaps also in Hardin, near the base of the formation and some eight or ten feet thick, is a dark-red color. There are perhaps other red-shale horizons in the formation. Other shale beds are of a distinctly olive-green color, and these red and green shales are a very characteristic feature of the formation in the more eastern portion of its extent. In this same region there are one or more remarkable chert horizons in the Kinaid. The more important of these is a massive bed three or more feet thick, commonly rather light colored, and in places with a slightly greenish tint. The resistant character of this chert makes it a conspicuous feature in places in the residuum from the formation as seen along roadsides, in stream beds, and on hillsides. In places subcubical masses of the chert a foot or more in dimension are strewn over the surface where the bed is present. There are other less conspicuous chert beds, some of them dark colored and similar in character to the chert that is so abundant in the Vienna limestone. The limestone layers of the Kinkaid in this more eastern region are quite similar in lithologic character to the beds in Randolph and Jackson counties.

The thickness of the Kinkaid limestone exhibits considerable variation due to the fact that it is the highest formation of the Chester series, and has consequently been subjected to the pre-Pennsylvanian erosion. Its greatest thickness in Jackson County is in excess of fifty feet, and it may vary from this maximum thickness to nothing at all, for in places the Pennsylvanian strata rest upon the Degonia sandstone. In the southern counties the formation is also variable in thickness, but on the whole it is notably thicker than it is north of Big Muddy River. At one locality in the bluffs northwest of Buncombe, in Johnson County, the limestone is about one hundred and forty feet thick and in the entire belt across the state the minimum thickness seems to be not less than sixty or seventy feet.

The fauna of the Kinkaid limestone, so far as it is known, is not so prolific as is that of several of the older limestones in the Chester series, but it resembles these earlier faunas in its general characters, consisting, as it does, of the same genera of brachiopods bryozoans, and blastoids. The pelecypod *Sulcatopinna missouriensis*, which is so characteristic of the Menard, is also present in the Kinkaid, and associated with it is the large form of *Spirifer increbescens*. The specimens of *Composita*, however, which have been met with in the Kinkaid, are of the smaller type, like those in the Middle and Lower Chester limestones. A form that is very common in the Kinkaid is a species of *Martinia*, a genus which is commonly wanting in other Upper Chester faunas, and is only locally common in the Middle and Lower Chester horizons. The bryozoans have nowhere been found to be so abundant or so well preserved in the Kinkaid as they are in the earlier Chester limestones, but those that are present are members of the same genera as are represented elsewhere, and most of the species are also believed to be present in the lower horizons.

GEOLOGICAL CROSS-SECTION

The relations of the several Chester formations in Illinois which have been described in the preceding pages are shown in the accompanying diagrammatic section. This section is intended to illustrate the sequence of beds from Hardin County at the southeast to Randolph and Monroe counties at the northwest. The sandstone units are shaded in the diagram, the limestone-shale units being left blank. The diagram has been constructed as if the upper units of the formational succession were continuous to the extreme northwestern extension of the Chester beds in St. Clair County. This is not the actual condition, however, for the entire series of beds is truncated by the Pottsville, so that these basal Pennsylvanian strata, in passing northward from Randolph

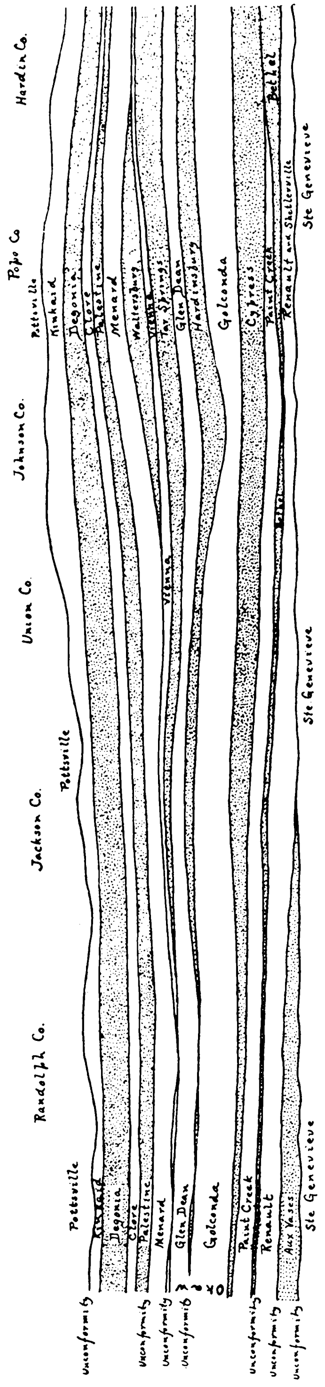

FIG. 1

through Monroe and into St. Clair counties, successively overlap the truncated Chester formations until they rest upon the Ste. Genevieve and St. Louis limestones whose position is beneath the Chester.

GEOLOGICAL HISTORY

In order to appreciate properly the historical relation of the Chester series in the Illinois basin to the Mississippian as a whole, it is desirable to outline somewhat briefly the succession of events which are recorded in the Lower Mississippian or Iowa series. The stratigraphic units which are commonly recognized in this series in the Mississippi Valley are as follows:

7. Ste. Genevieve limestone
6. St. Louis limestone
5. Spergen limestone
4. Warsaw limestone and shale
3. Keokuk limestone
2. Burlington limestone
1. Kinderhook group

Throughout this basin the oldest of the Mississippian formations belonging to the Kinderhook group rest unconformably upon whatever beds underlie them, unless possibly there may be a continuity of sedimentation from Devonian time in southeastern Iowa. There is some reason to believe that the oldest Kinderhook beds at Burlington, Iowa, the blue shales beneath the Chonopectus sandstone, are continuous with the Sweetland Creek shales which commonly have been placed in the Upper Devonian. However, the Sweetland Creek shales are unconformable upon the beds beneath them, and it is possible that the whole of the Sweetland Creek shale should be placed in the Mississippian. This condition of unconformity of the Kinderhook upon underlying formations of various ages persists entirely around the Ozark region of Missouri and northern Arkansas. This situation shows that preceding Kinderhook time the waters were withdrawn from the Mississippi Valley basin, at least north of the Ohio River, and possibly were withdrawn from the entire continent. The details of the first advance of the Mississippian waters cannot be discussed in this place, but the sediments recording this epoch are exceedingly various in character, there being sandstones, shales, and limestones. As the waters advanced the Ozark land mass was at last largely or perhaps wholly submerged, and the mainland shore line of the Illinois basin crossed northern Illinois or southern Wisconsin and continued westward into Iowa. The position of this shore line was certainly north of Chicago, as is evidenced by the typical Lower Burlington fauna which has been recorded from the northern part of that city.[1] At this time the waters covering southeastern Iowa, the Ozark region of Missouri, and the adjacent parts of Illinois were quite free from land wash, and the very pure Burlington limestone was being deposited throughout this region. During Keokuk time there was a shifting of the northern shore line in a southerly direction, to such a position that a certain amount of clastic material was washed into that part of the sea which covered southeastern Iowa and the adjacent parts of Missouri and Illinois. The presence of this land wash is shown in the shaly beds which are present in the more northerly Keokuk exposures, a lithologic character which differentiates the Keokuk from the underlying Burlington limestone. Farther south in Illinois and in Missouri, both in the southeastern and southwestern parts of the state, at a greater distance from the shore line, these clastic beds are not present in the Keokuk, a condition that makes the lithologic separation of the Burlington and Keokuk somewhat difficult.

---

[1] Davis, *Jour. Geol.*, Vol. XXV (1917), pp. 576–83.

In southeastern Iowa the land-derived sediments became more dominant in Warsaw time, although there is no stratigraphic break between the Keokuk and the Warsaw. Farther south in the Mississippi Valley basin, limestone deposition continued into Warsaw time, and in southwestern Missouri shale deposition of this age is absent or practically absent throughout the entire epoch. During Warsaw time, however, the northern shore of the basin continued its southward migration and by mid-Warsaw time it doubtless occupied a position somewhere between the southern border of Iowa and St. Louis, Missouri, and at this time the clastic sediment extended as far south as southeastern Missouri. The lower Warsaw only, therefore, was deposited in southern Iowa.

During Spergen time the sea readvanced to the north and again occupied what is now southeastern Iowa, where the Spergen limestone rests unconformably upon the Warsaw and where locally much or all of the lower Warsaw that had been deposited was eroded during the time when the shore line occupied a more southern position and when this part of Iowa was an area of dry land. At St. Louis and to the south the Warsaw sedimentation passed without interruption into the Spergen, but with the northward shifting of the shore line of the basin and the consequent greater remoteness of the region from the source of land wash pure limestone sedimentation without clastic materials of any sort was reinitiated.

During the later portion of Spergen time the shore line again shifted to the south, and must have occupied about the position of the late Warsaw land margin. This was followed by another shift to the north, which is evidenced by the unconformable relations of the lower St. Louis in Iowa, resting upon the eroded surface of the Spergen, the erosion in places having even cut through the Spergen, so that the higher formation rests upon beds of Warsaw age. Another oscillation of the shore line occurred in mid-St. Louis time, for the upper St. Louis beds in Iowa are separated by a distinct erosional unconformity from the lower St.

Louis, and this stratigraphic break is probably exhibited in the very greatly brecciated zone in the midst of the St. Louis limestone as far south as Alton, Illinois.[1]

In the region south from St. Louis, during all this time, the sedimentation had been continuous with no interruption whatsoever, showing that the Mississippian sea had continually occupied this southern portion of the basin. At the close of St. Louis time, however, a greater oscillation in the sea-level occurred, and the waters were withdrawn to some extent from the Ozark land as well as from Iowa and from all of the region between Iowa and Ozarkia. This withdrawal was only temporary, however, for the sea reoccupied the entire region and in it the Ste. Genevieve limestone was deposited unconformably upon the St. Louis. This sub-Ste. Genevieve unconformity is well exhibited near Ste. Genevieve, Missouri, and wherever the Ste. Genevieve limestone is present to the north of this locality to its most extreme northern outcrops in the Des Moines Valley of Iowa, near Fort Dodge. In a southeasterly direction from Ozarkia, however, in Hardin County, Illinois, sedimentation was continuous from the St. Louis into the Ste. Genevieve limestones, with no interruption of any sort, showing that the Mississippian sea continuously occupied this portion of the Illinois basin. The record of the extension of the Ste. Genevieve sea to the north and west of Ozarkia is obscured by the presence of younger sediments, but it is not unlikely that this ancient island was entirely surrounded at this time. Following Ste. Genevieve time the sea withdrew completely from the Illinois basin. Wherever the Chester formations are present their faunas appear abruptly, and wherever the sections have been examined critically there is evidence of unconformity between them and the underlying formations.

In summing up the history of the Illinois basin in Lower Mississippian time, the succession of events consists of oscillatory movements of the sea occupying the basin, these oscillations being exhibited by the shifting of the bounding shore line of the basin from north to south and back again to the north. The greatest northern extension of the basin was early in Mississippian time, the successive reoccupations of the region perhaps falling a little short each time of the previous one, and the successive withdrawals perhaps being a little greater each time until the final withdrawal at the close of Ste. Genevieve time. With each readvance of the sea to the north, however, essentially the same basin was reoccupied, so that the sea-pattern during all of this time, in the periods of greater submergence, remained practically the same, differing only in more or less minor details. During each interval of submergence in this period, the sea spread far to the north in Illinois, and westward in Iowa, and doubtless also in northern Missouri, surrounding and perhaps completely submerging at times the Ozark Island, and doubtless was connected with the seas which extended westward to the Rocky Mountain land.

---

[1] These statements concerning the stratigraphic relations in southeastern Iowa are based chiefly upon the field observations of Dr. J. M. Van Tuyl.

With the return of the seas into the Illinois basin at the beginning of Upper Mississippian or Chester time, the conditions indicated by the sedimentary record were very different from those that had existed earlier. In the earlier period almost no sand deposits were accumulated anywhere in the region except in Kinderhook time, during the initial submergence of the basin, the only exception to this being the presence of the thin Rosiclare sandstone layer that is present in the Ste. Genevieve limestone in most sections. In Chester time, as has already been shown in the discussion of the successive formations, thick deposits of sand were accumulated, and most of the limestones were associated with large amounts of clastic material in the form of shales, these shaly Chester limestones being in strong contrast with the great thicknesses of nearly pure, massively bedded limestones of the Lower Mississippian. The original source of all these accumulations of Chester sand is not entirely clear. The Aux Vases sandstone at the base, which is thickest toward the eastern shore of Ozarkia and thins southeastwardly to nothing, may have been derived from the wearing away of some of the more ancient sandstones of Ozarkia, but such sandstones as the Bethel, Cypress, Hardinsburg, and Tar Springs, which are thick formations in southeastern Illinois and beyond in Kentucky, becoming much reduced or even absent altogether toward the shore of Ozarkia, could not have had such a source. The sand of these formations may have been derived from the Appalachian land, still farther to the east. The Palestine and Degonia sandtones, which are almost equally thick clear across Illinois, belong in still another category. The Waltersburg sandstone differs in distribution from all of the others, being essentially restricted to an area about forty miles in width east and west, with an unknown extent in a north-south direction. This may be an accumulation in the form of a delta at the mouth of some stream from the north, which emptied into the Illinois basin, perhaps bringing the sand from some far-distant region. The origin of such sands as the Palestine and Degonia, which are more uniformly developed across the entire basin, and even some of the others which are less uniformly developed, may have been from more than one source.

The lateral distribution of the sands of the Chester series in the Illinois basin was doubtless through the agency of wave action along the shore line. During the stages of withdrawal of the waters in the basin, those shore sands, left high and dry, would be subjected to erosion and to transportation southward and redeposition, and to re-working in the next following advance of the waters. In this manner the same sand may have been worked over and over again in the shore deposits of the basin, a condition which may account in part at least for the great similarity between the several sandstone formations of the series.

The areal distribution of the Chester formations is very different from that of the Lower Mississippian. The northernmost exposures of the Chester is in the Mississippi River bluff in St. Clair County, Illinois, about one-half mile north of the St. Clair–Monroe County boundary line, opposite Bixby. Beyond this point the Chester formations are covered by the Pennsylvanian, but well records indicate that they swing off to the northeast from the last exposure to the vicinity of Decatur, Illinois, and from there continue in a southeasterly direction, passing into Indiana. These formations, therefore, were deposited in a basin lying between Ozarkia on the west and Cincinnatia on the east, with its northernmost extremity near the center of Illinois. This basin had a very different outline from that in which the Lower Mississippian beds were laid down, the older basin extending much farther north and reaching westward into northern Missouri and Iowa, probably surrounding or submerging the Ozark land. The sea-pattern, then, of Chester time was quite different from that of the earlier Mississippian. The succession of sandstones and limestone-shale formations laid down in this basin in Chester time indicate a series of oscillations of the sea occupying the basin, comparable in a way to the oscillations in the much larger basin of Lower Mississippian time.

Throughout the alternating succession of Chester formations, the several units should be considered in pairs, each pair consisting of a sandstone formation below, passing upward into a limestone-shale formation. In a number of horizons in the series the sandstone formation clearly exhibits an unconformable contact with the underlying limestone, but in no case is there any evidence of unconformity between the sandstone and the overlying limestone-shale unit. Each one of these pairs doubtless represents one oscillatory advance and retreat of the waters of the basin, the lower sandstone unit in the pair being a transgressing formation associated with the advancing submergence, the limestone and shale deposition lagging behind the sand accumulation at a greater distance from the shore line. In so far as the sandstones lie unconformably upon the underlying limestone the magnitude of the oscillation has been sufficient to cause the waters of the basin to withdraw to a position south of the localities where observations upon surface outcrops have been possible. If the horizons of such unconformities could be traced southward toward the open sea of the period, they would presumably pass into entirely uninterrupted series of sediments, and if they could be followed still farther in the same direction the sandstone members in the succession of beds should disappear and a continuous limestone formation should represent the Chester series. At those horizons where no evidence of unconformity between the sandstone and the underlying limestone exists, the southernmost position of the retreating shore line of the basin was presumably somewhat north of the localities where the outcrops have been observed, and if the position of the ancient shore line at a period of emergence crossed the present belt of outcrop of the formations, the unconformity might be looked for over part of the area and be entirely absent elsewhere.

With each readvance of the Chester sea in the Illinois basin, prolific invertebrate faunas occupied the waters, and their fossil remains have been preserved in the limestones and calcareous shales. These successive faunas were much alike in many respects, but as they are critically studied, it is found that each one of them possesses certain characteristics which serve to differentiate it from the others. Farther to the south or southwest, beyond the area of alternating land and sea conditions which obtained within the Illinois basin, the Chester fauna was doubtless undergoing a continuous, normal, evolutionary development, and the successive stages of this evolution, modified more or less by the local environmental conditions, are mirrored in the successive faunas of the several calcareous formations in the Chester section of the Illinois basin.

The succession of events that has been outlined has an important bearing upon the interpretation of the Mississippian period of North America. In his "Revision of the Paleozoic Systems," Ulrich[1] has split the Mississippian into two so-called systems, the Waverlyan below and the Tennesseean above, the line of cleavage between the two being placed between the Warsaw and Keokuk formations. From the evidence afforded by the Mississippi Valley section of the Mississippian, which is the type section of these strata, there is less reason for placing a major dividing line at this horizon than at almost any other position in the entire succession of formations, and there is no basis whatsoever for the recognition of the so-called Waverlyan and Tennesseean as systems. There are, however, many excellent reasons for making a lower and upper division of the Mississippian, the line of separation being at the base of the Chester series. This position is approximately at the horizon where Ulrich has subdivided his Tennesseean into the Meramecian and Chesterian, but even here he has made a grave error in including the Ste. Genevieve limestone in the Chesterian. This error was introduced by his failure to separate the Renault limestone of western Kentucky and southern Illinois from the underlying Ste. Genevieve limestone. The Renault, or Renault-Shetlerville, actually lies unconformably upon the Ste. Genevieve in the sections examined by Ulrich, with the Aux Vases sandstone of the Mississippi Valley section wanting. The characteristic Chester fauna of the Renault limestone, mistakenly included in the Ste. Genevieve by Ulrich, led him to assign the whole of the Ste. Genevieve to the Chester. Although there is some passing of species from the Ste. Genevieve into the basal Chester, long experience in the field has demonstrated that the really characteristic Ste. Genevieve fossils species do not pass into the Renault or basal Chester, and long-continued faunal studies based upon extensive collections have shown that by far the most important faunal break in this portion of the stratigraphic sequence occurs in passing from the Ste. Genevieve limestone to the overlying Chester. This important faunal break, associated with the unconformable relation of the Chester sediments upon the underlying formations, wherever this portion of the section is exhibited, and also associated with the distinct change in sea-pattern in passing from the Ste. Genevieve to the Chester in the Illinois basin, seems to afford an abundance of evidence of various sorts for placing the major line of division within the Mississippian at the top of the Ste. Genevieve limestone. In the Mississippi River counties of Illinois this line is at the base of the Aux Vases sandstone, while in the more southern counties of the state it is at the base of the Shetlerville-Renault limestone unit. The two so constituted divisions of the Mississippian are of sufficient importance to rank as series, the Mississippian as a whole constituting a system.

---

[1] *Bull. Geol. Soc. Amer.*, Vol. XXII (1910), Plate XXIX, opp. p. 609.

[*Concluded*]